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Several recent reports exemplify the increasing frequency with which Giardia is being implicated as the cause of waterborne outbreaks of diarrhea. These and past outbreaks have several features in common, namely that they occur in communities in which 1) surface water (streams, rivers, lakes), not well water, is used; 2)chlorination is the principal method for disinfecting water; and 3) water treatment does not include filtration, or existing filters have structural or operational defects.

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Journal Article

Epidemiologic Notes and Reports

Waterborne Giardiasis — California, Colorado, Oregon, Pennsylvania

Several recent reports exemplify the increasing frequency with which *Giardia* is being implicated as the cause of waterborne outbreaks of diarrhea. These and past outbreaks have several features in common, namely that they occur in communities in which 1) surface water (streams, rivers, lakes), not well water, is used; 2) chlorination is the principal method for disinfecting water; and 3) water treatment does not include filtration, or existing filters have structural or operational defects.

California: From January 1976 through September 1979, 42 cases of giardiasis were confirmed in Plumas County residents or vacationers. Preliminary investigation disclosed that most had occurred in the spring and summer months and were predominantly in persons from the town of Graeagle.

In September 1979, a survey was undertaken of 378 subscribers of the Graeagle Water Company and 200 randomly selected control households in a neighboring town. The Graeagle Water Company employs a surface water source which is chlorinated but unfiltered, whereas the water supply of the control town uses well water. Responses from the Graeagle subscribers reported on a total of 463 people. Of these, 79 (17%)—including 19 previously confirmed cases—gave histories suggestive of giardiasis (that is, diarrhea of ≥5 days duration or recurrent diarrhea accompanied by 2 or more of the following symptoms—abdominal pain, fever, bloating, nausea, vomiting, and weight loss). In contrast, 3% of the residents in the control town had an illness compatible with *Giardia*. Among confirmed cases, exposure to the Graeagle water system was the only common risk factor identified. Attempts by the California Department of Health Services to isolate *G. lamblia* cysts from Graeagle water samples were unsuccessful. However, 2 of 3 beavers trapped in the Graeagle watershed were found to be infected with the organism. An ordinance to boil all water was put into effect in Plumas County until the water could be filtered.

Colorado: During August 1979, giardiasis-like illness was reported from both residents of and visitors to Estes Park, Colorado. Sixteen of 28 stool specimens from residents examined by the Colorado State Department of Health were found to be positive for *G. lamblia*. During the month of August 1978, 3 of 17 (17%) stools examined were found to be positive for *Giardia*.

Estes Park is a resort town and receives water from the Fall River plant, which utilizes surface water that is both filtered and chlorinated. A study of Estes Park residents supplied with water from the Fall River plant and a control population supplied with water from other Estes water plants revealed no difference in the attack rate for giardiasis, defined as any diarrheal illness persisting for 7 days or more during the study period (August 1-September 19, 1979). However, a study of 23 nonresidents of Estes Park who visited the

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town during the study period showed that 7 of 23 (31%) were ill; 7 of 11 (63%) people remembered drinking water at establishments supplied by the Fall River plant, whereas none of the 12 who did not drink water from establishments supplied by the Fall River plant became ill ($P<.01$, Fisher's exact test). Eight of the 13 high-volume water-sampling filters placed at different locations in Estes Park and Denver were positive for *G. lamblia* cysts. Positive samples were obtained from water collected before and after treatment at the Fall River plant. The plant has been closed and will not be reopened until new chemical and filtration measures are instituted.

Oregon: Giardiasis outbreaks occurred in 2 communities in Oregon in 1979. The first outbreak was in a mountain resort community at Zig Zag in September 1979. Epidemiologic investigation showed that 66 of 690 individuals (10%) reported intestinal symptoms consistent with giardiasis. Sixteen of 66 (24%) were treated for giardiasis, and 8 of 16 were found to have *Giardia* cysts in their stools. A study of the water system showed *Giardia* cysts in beaver feces collected from the watershed. *Giardia* cysts were also found at the distribution system at the chlorinator station.

The second outbreak occurred in Government Camp in November. Several cases of giardiasis were reported among persons who drank the chlorinated, but unfiltered, water in this resort community. An epidemiologic investigation of permanent residents of Government Camp showed that 55 of 95 (58%) had gastrointestinal illness during October-November 1979; 20 of 95 (21%) had diarrhea, gas, or cramps lasting 7 days or more. Seven of 95 (7%) had laboratory-confirmed giardiasis. A study of a control community using a different water source showed that 50 of 151 (33%) had gastrointestinal illness during the study period, with 12 of 151 (8%) having symptoms suggestive of giardiasis. None were found to have *Giardia* in their stools. The differences between these 2 communities were statistically significant. *Giardia lamblia* cysts were identified in beaver feces collected from the stream above the intake of the Government Camp water system. An ordinance to boil water was issued.

Pennsylvania: During the 8-week period October 20-December 15, 1979, 407 cases of giardiasis were confirmed among the residents of Bradford. Epidemiologic investigation showed that the illness had begun as early as July, but cases peaked in September and October. The cases were widespread, and geographic clustering was not evident.

The water supply of Bradford is disinfected by chlorine gas; the water is not filtered. A marked turbidity problem was reported in July and August; it was attributed to a prolonged rainy season. Intermittently, high coliform counts and high turbidity levels were measured in the finished water. *Giardia* cysts were recovered from both raw and treated water. *Giardia* was also identified in the stool of a beaver trapped in 1 of the water supply reservoirs.

A random community questionnaire survey of Bradford showed that 5.4% had giardiasis-like illness (diarrhea for $\geq$10 days) vs. only 0.6% of Warren County residents who used well water as their source ($X^2 = 9.58$, $P \leq .002$). During July-October 1979, 25% of Bradford residents had diarrheal illness compared to 10% of Warren County residents ($X^2 = 19.88$, $P \leq .0001$). A stool survey confirmed *Giardia* infection in 17 (16%) of 106 Bradford residents compared to none of 40 from the control county ($P<.003$, Fisher's exact test). To control the outbreak the chlorine level in the water was increased to 2-3 ppm and an ordinance to boil water was issued.

Reported by A Keifer, MD, G Lynch, Plumas County Health Dept, D Conwill, MD, RR Roberto, MD, MPH, C Powers, MS, J Gaston, MS, California State Dept of Health Services, in the California Morbidity Weekly Report, November 23, 1979; RW Sherwood, MD, MPH, L Johnston, PhD, Larimer County Health Dept, Fort Collins, Colorado; J Blair, B Early, RS Hopkins, MD, State Epidemiologist, E Scott, R Smade, Colorado State Dept of Health; H Osterud, MD, N Slifman, MD, University of Oregon

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Editorial Note: The long-term solution to waterborne giardiasis requires improvements in and widespread use of water filtration. In the meantime, there is a continuing need to provide potable drinking water on an emergency basis to communities experiencing an outbreak. This has been accomplished in some communities by switching from surface water to well water sources, transporting drinking water from a nearby community whose water supply is not affected, and using bottled water. However, in most instances alternative water supplies have not been readily available, and the costs of transporting water have been prohibitive. The only alternative in these situations is to kill *Giardia* cysts in the existing water supply. Regardless of the method used, it must be continued until the source of water contamination is eliminated or until the deficiencies in water treatment are corrected. Boiling is the most reliable method for killing *Giardia* cysts in water. Although time/temperature studies have not been done to determine the thermal death point of *Giardia* cysts, data are available on *Ascaris* eggs, acknowledged by most parasitologists to be the most resistant of parasite eggs and more resistant to physical and chemical factors than protozoan cysts. *Ascaris* eggs are immediately killed at 70 C (*1*). Since *Giardia* cysts would succumb to even lower temperatures, simply bringing drinking water to a boil is considered more than adequate to kill *Giardia* cysts. In circumstances where gross fecal contamination of the water supply is evident, boiling water for a longer period of time may be warranted to kill other enteric pathogens.

The effects of chemical disinfectants on *Giardia* cysts have received only limited study. It is evident from these and other outbreaks that chlorine levels used in routine disinfection of municipal drinking water (0.4 mg/l free chlorine) are not effective against *Giardia* cysts. Recent experimental data suggest that hyperchlorination (5-9 mg/l free chlorine residual) may kill *Giardia* cysts (*2,3*). To determine the viability of cysts following exposure to various concentrations of chlorine, the investigators employed a recently developed method for inducing *Giardia* cysts to excyst *in vitro*. If *Giardia* cysts failed to excyst after treatment with chlorine, they were assumed to be dead. However, animal infectivity studies to validate the reliability of this technique for assessing viability have not been done. The amount of chlorine required to inhibit excystation of *Giardia* cysts depends on the water temperature, pH, turbidity, and contact time between the parasite and chlorine. In general, higher concentrations of chlorine are required for water that is cold (3-5 C), has an alkaline pH, or is turbid. Chlorine concentrations may be decreased if contact time with the organism is increased. By manipulating these variables it may be possible to reduce free chlorine residual to a level that would be satisfactory for use in municipal drinking water and still be effective against *Giardia* cysts. The minimum chlorine levels and optimal water conditions necessary to kill *Giardia* cysts in municipal water supplies are yet to be determined.

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